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16 DEC 2003

# ertifikaat / Certificate

ATENTKANTOOR REPUBLIC OF SOUTH AFRICA — REPUBLIEK VAN SUID-AFRIKA PATENT OFFICE

EPARTEMENT VAN HANDEL EN NYWERHEID — DEPARTMENT OF TRADE AND INDUSTRY

Hiermee word gesertifiseer dat
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the documents annexed hereto are true copies of:

Application form P.1 and P.3, provisional specification and drawings of South African Patent Application No. **2002/9607** as originally filed in the Republic of South Africa on **26 November 2002** in the name of **SHOCK-DOC LTD** for an invention entitled:

**"MONITORING OF SHOCK ABSORBERS".**

**PRIORITY DOCUMENT**
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Geteken te / Signed at PRETORIA in die Republiek van Suid-Afrika, hierdie / in the Republic of South Africa, this **10th** dag van / day of **December 2003**

*Registrateur van Patente*

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
APPLICATION FOR A PATENT
ACKNOWLEDGEMENT OF REC
(Section 30(1) Regulation 22)

FORM P.1
(to be lodged in duplicate)

THE GRANT OF A PATENT IS HEREBY REQUESTED BY THE UNDERMENTIONED APPLICANT ON THE BASIS OF THE PRESENT APPLICATION FILED IN DUPLICATE

| 21 | 01 | PATENT APPLICATION NO | 2002/9607 | A&A REF | V15504 |
|---|---|---|---|---|---|

71 FULL NAME(S) OF APPLICANT(S)

SHOCK-DOC LTD

ADDRESS(ES) OF APPLICANT(S)

PRICEWATERHOUSECOOPERS, 32 IDA STREET, MENLO PARK, 0102,
REPUBLIC OF SOUTH AFRCA

54 TITLE OF INVENTION

MONITORING OF SHOCK ABSORBERS

Only the items marked with an "X" in the blocks below are applicable.

[ ] THE APPLICANT CLAIMS PRIORITY AS SET OUT ON THE ACCOMPANYING FORM P.2. The earliest priority claimed is

Country: No: Date:

[ ] THE APPLICATION IS FOR A PATENT OF ADDITION TO PATENT APPLICATION NO 21 01

[ ] THIS APPLICATION IS A FRESH APPLICATION IN TERMS OF SECTION 37 AND BASED ON APPLICATION NO 21 01

THIS APPLICATION IS ACCOMPANIED BY:

| | |
|---|---|
| X | A single copy of a provisional specification of 12 pages |
| X | Drawings of 2 sheets |
| | Publication particulars and abstract (Form P.8 in duplicate) (for complete only) |
| | A copy of Figure of the drawings (if any) for the abstract (for complete only) |
| X | An assignment of invention |
| | Certified priority document(s). (State quantity) |
| | Translation of the priority document(s) |
| | An assignment of priority rights |
| | A copy of Form P.2 and the specification of RSA Patent Application No 21 01 |
| X | Form P.2 in duplicate |
| X | A declaration and power of attorney on Form P.3 |
| | Request for ante-dating on Form P.4 |
| | Request for classification on Form P.9 |
| | Request for delay of acceptance on Form P.4 |
| | Extra copy of informal drawings (for complete only) |

74 ADDRESS FOR SERVICE: Adams & Adams, Pretoria

Dated this 26 day of November 2002

ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS

The duplicate will be returned to the applicant's address for service as proof of lodging but is not valid unless endorsed with official stamp

A&A P2/1

OFFICIAL DATE STAMP

2002-11-26

REGISTRAR OF PATENTS

ADAMS & ADAMS REPUBLIC OF SOUTH AFRICA FORM P.3
PRETORIA PATENTS ACT, [redacted]
**DECLARATION AND [redacted]ER OF ATTORNEY**
(Section 30 - Regulation 8, 22(i)(c) and 33)

| PATENT APPLICATION NO | A&A Ref: V15504 | LODGING DATE |
|---|---|---|
| 21 01 2002/9607 | | 22 26 November 2002 |

| FULL NAME(S) OF APPLICANT(S) |
|---|
| 71 SHOCK-DOC LTD |

| FULL NAME(S) OF INVENTOR(S) |
|---|
| 72 1. VENTER, Frederik Petrus<br>2. VENTER, Michael Jacobus<br>3. VENTER, Hermanus Nicolaas<br>4. BRESLER, Johanna Frederika |

| EARLIEST PRIORITY CLAIMED | COUNTRY | | NUMBER | | DATE | |
|---|---|---|---|---|---|---|
| | 33 | NIL | 31 | NIL | 32 | NIL |

NOTE: The country must be indicated by its International Abbreviation - see schedule 4 of the Regulations

| TITLE OF INVENTION |
|---|
| 54 MONITORING OF SHOCK ABSORBERS |

* I/We
VENTER, Martin Jacobus
hereby declare that :-

~~1. I/we am/are the applicant(s) mentioned above;~~

** 2. I/we have been authorized by the applicant(s) to make this declaration and have knowledge of the facts herein stated in the capacity of MANAGING DIRECTOR of the applicant(s);

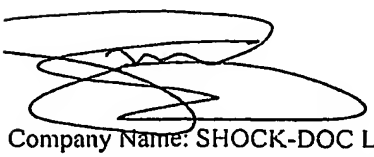
*** 3. the inventor(s) of the abovementioned invention is/are the person(s) named above and the applicant(s) has/have acquired the right to apply by virtue of an assignment from the inventor(s);

4. to the best of my/our knowledge and belief, if a patent is granted on the application, there will be no lawful ground for the revocation of the patent;

**** ~~5. this is a convention application and the earliest application from which priority is claimed as set out above is the first application in a convention country in respect of the invention claimed in any of the claims; and~~

6. the partners and qualified staff of the firm of **ADAMS & ADAMS**, patent attorneys, are authorised, jointly and severally, with powers of substitution and revocation, to represent the applicant(s) in this application and to be the address for service of the applicant(s) while the application is pending and after a patent has been granted on the application.

SIGNED THIS 25th DAY OF November 2002

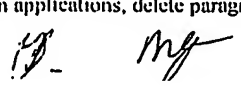


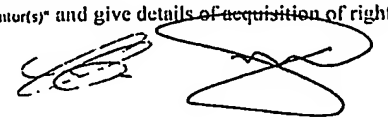
Company Name: SHOCK-DOC LTD
Full Names: VENTER, Martin Jacobus
Capacity: MANAGING DIRECTOR

(no legalization necessary)

* In the case of application in the name of a company, partnership or firm, give full names of signatory/signatories, delete paragraph 1, and enter capacity of each signatory in paragraph 2.
** If the applicant is a natural person, delete paragraph 2.
*** If the right to apply is not by virtue of an assignment from the inventor(s), delete "an assignment from the inventor(s)" and give details ~~of acquisition~~ of right.
**** For non-convention applications, delete paragraph 5.







2002/9607

# CONFIRMATION OF ASSIGNMENT OR ASSIGNMENT OF INVENTION, DESIGN AND COPYRIGHT

A & A Ref: V15504

WHEREAS I/We *(a)*

1. VENTER, Frederik Petrus
2. VENTER, Michael Jacobus
3. VENTER, Hermanus Nicolaas
4. BRESLER, Johanna Frederika

hereinafter referred to as the ASSIGNOR(S)

of *(b)*

1. Plaas Bokfontein, District Brits, Republic of South Africa
2. 25 Palm Boulevard, Wapadrand Road, Wapadrand, Pretoria, Republic of South Africa
3. Plaas Bokfontein, District Brits, Republic of South Africa
4. 101 Knoppies Doring, Onverwacht, Ellisras, Republic of South Africa

am/are the inventor(s)/author(s) or am/are joint inventor(s)/author(s) with

of an invention and/or design entitled: *(c)*

MONITORING OF SHOCK ABSORBERS

hereinafter referred to as 'the invention', and of certain literary and artistic works relating to the invention and including any notes, memoranda, reports, sketches, drawings, plans, photographs and all associated illustrations and handwritten, typewritten and printed matter, of whatever description, regarding the invention, hereinafter collectively referred to as 'the work';

AND WHEREAS *(d)*

SHOCK-DOC LTD

hereinafter referred to as the ASSIGNEE(S)

of *(e)*

~~38 18th Street, Menlo Park, 0081, Republic of South Africa~~

PRICEWATERHOUSECOOPERS, 32 IDA STREET, MENLO PARK, 0102, REPUBLIC OF SOUTH AFRICA

has/have for good and sufficient consideration agreed to acquire/has/have acquired all my/our right, title and interest in and to the invention, the design, and the copyright in the work from me/us in respect of all countries in the world.

NOW THEREFORE, for one US $ or other good and valuable consideration,

*(f)* I/we hereby assign to the ASSIGNEE(S)

OR

*(g)* I/we hereby confirm that by virtue of a previous agreement the ASSIGNEE(S) has/have acquired,

OR

*(h)* I/we hereby confirm that the ASSIGNEE(S) has/have acquired by virtue of my/our having been an employee/director/member of the ASSIGNEE(S) and the invention and/or design and/or work having been made in the course and scope of my/our being an employee/director/member of the ASSIGNEE(S)

for all countries in the world all my/our right, title and interest in and to the invention, in and to the design, and the copyright in the work, including any further developments and improvements in respect thereof, for all countries in the world with the right to apply for a patent, or one or more design and copyright registrations in his/their own name(s); and I/we hereby undertake at any time when called upon by the assignee(s), his/their successors or assigns to render every assistance and to execute promptly all papers, forms or documents required to secure the filing of patent and/or design and/or copyright applications in other countries in the name of the assignee(s), his/their successors or assigns, or, in countries where such applications can only be filed by inventors, to do so in my/our own name(s) and then to secure the formal registration of such assignments there in accordance with the laws of the countries concerned as are needed to transfer the applications or any patents granted thereon, to the ASSIGNEE; and generally I/we undertake, without requiring any further consideration, to render every assistance which may be needed to ensure that patent, design and copyright registrations are granted in favour of the assignee(s), his/their successors or assigns, on all patent and/or design and/or copyright applications filed for the work and for any further developments and improvements in respect thereof; and in order to give effect to the terms and conditions embodied herein, I/we hereby irrevocably grant unto the assignee(s), his/their successors or assigns, my/our Power of Attorney with power of substitution and revocation to act on my/our behalf, as if personally acting in the execution of such papers, forms or documents envisaged above, such Power of Attorney incorporated in this agreement being dated as of the date set out hereunder above my/our signatures; and I/we agree that the law governing the agreement and Power of Attorney incorporated therein, shall be the law of the Republic of South Africa;

and I/we, the Assignee(s), hereby accept(s) the above undertakings and assignment/confirm the undertaking and assignment as set out above.

The assignment(f)/agreement(g) above is made effective from the date of execution, or the date of filing of the application for the invention in the Republic of South Africa, or the date of execution of the Form P3 for the invention, whichever date is earliest.

DATED this *(i)* 25th day of November 2002

*(j)* _____
*VENTER, Frederik Petrus*

*(k)* _____
*VENTER, Michael Jacobus*

*(l)* _____
*VENTER, Hermanus Nicolaas*

*(m)* _____
*BRESLER, Johanna Frederika*

*(n)* _____
*Company: ~~STOCK-DOC~~ LTD*
*Full Names: ~~VENTER~~, Martin Jacobus*
*Capacity: Managing Director*

NOTE: No witness or legalisation is necessary

**ADAMS & ADAMS**
Patent and Trade Mark Attorneys
**PRETORIA**

| | |
|---|---|
| (a) | Inventor's(s')/Author's(s') full name(s). |
| (b) | Inventor's(s')/Author's(s') address(es) (not PO Box number). |
| (c) | Title of Invention. |
| (d) | Assignee's('s) name or names. |
| (e) | Assignee's(s') address(es) (not PO Box number but a residential address or a registered office address of a company. |
| (f), (g), (h) | Delete whichever is inapplicable. |
| (i) | Date of Execution. |
| (j), (k), (l), (m) | Signature(s) of Inventor(s)/Author(s). |
| (nl) | Signature(s) of Assignee(s). |

A & A Ref No: V15504

ADAMS & ADAMS
PATENT ATTORNEYS
PRETORIA

FORM P6

REPUBLIC OF SOUTH AFRICA
Patents Act, 1978

# PROVISIONAL SPECIFICATION

(Section 30 (1) - Regulation 27)

| 21 | 01 | OFFICIAL APPLICATION NO |
|---|---|---|

2002/9607

| 22 | LODGING DATE |
|---|---|

26 November 2002

| 71 | FULL NAME(S) OF APPLICANT(S) |
|---|---|

**SHOCK-DOC LTD**

| 72 | FULL NAME(S) OF INVENTOR(S) |
|---|---|

1. **VENTER, Frederik Petrus**
2. **VENTER, Michael Jacobus**
3. **VENTER, Hermanus Nicolaas**
4. **BRESLER, Johanna Frederika**

| 54 | TITLE OF INVENTION |
|---|---|

**MONITORING OF SHOCK ABSORBERS**

THIS INVENTION relates to the monitoring of shock absorbers, particularly, but not exclusively, for use on, or fitted to, a vehicle suspension.

In accordance with the invention, a method of determining the damping factor of a shock absorber includes

attaching an accelerometer to one of a first part and a second part of the shock absorber;

displacing the first and second parts of the shock absorber relative to one another;

measuring the acceleration of the parts of the shock absorber relative to each other by reading a signal from the accelerometer thereby to determine the damping factor of the shock absorber by use of the signal.

Further in accordance with the invention, there is provided a shock absorber monitoring system, which includes

an accelerometer for generating an acceleration value, the accelerometer being removably attachable to a first part of the shock absorber;

a processor in communication with the accelerometer, to receive the acceleration signal and to determine the damping factor of the shock absorber when the first part of the shock absorber is displaced relative to a second part of the shock absorber; and

an indicator responsive to the processor for displaying a value representative of the damping factor of the shock absorber.

The shock absorber may be monitored as a unit removed from a vehicle or the like. The shock absorber may also be monitored while it is fixed to a suspension of a vehicle. The method may then include attaching the accelerometer to a vehicle body proximate the shock absorber to be monitored, for example, proximate one of the wheels of the vehicle, thereby to determine the damping factor of the shock absorber at the wheel and limiting the effect of the shock absorbers at other wheels of the vehicle.

The accelerometer may include attachment means, to permit removable attachment to the vehicle body, or to one part of the shock absorber. The attachment means may, for example, include a magnetic coupling device, a suction cup, or the like.

Incidental acceleration values of the first part of the shock absorber may be measured at discrete time intervals over a period of time.

The determining of the damping factor may include performing a mathematical calculation on a series of acceleration values.

The mathematical calculation may include mathematically integrating the series of acceleration values over the period of time to obtain a series of incidental velocity values over the period of time, and mathematically integrating the series of velocity values over the period of time to obtain a series of incidental position values over the period of time.

The calculation may include mathematically modelling the movement properties of the suspension with a differential equation. More specifically, the movement properties may be modelled by a second order differential equation.

The calculation may include mathematically solving the differential equation in a time domain, thereby obtaining a theoretical solution to a series of theoretical position values over the period of time.

The calculation may include fitting the series of theoretical position values over the period of time to the series of calculated position values over the period of time by means of an iterative curve fitting algorithm such as a "Nelder Mead" algorithm. When the curve of the series of theoretical position values over the period of time is fitted within tolerable limits to the series of calculated position values over the period of time, the calculated damping constant, which is a theoretical approximation of the damping factor of the shock absorber, is obtained.

The method may include comparing the calculated damping factor with qualitative data from a manufacturer of the shock absorber, and indicating whether the damping factor falls within tolerable limits of the qualitative data.

Hence, the shock absorber monitoring system may include a storage device on which a set of instructions are stored, which when executed by the processor directs the processor to perform the mathematical calculations as herein described.

The accelerometer may be remote from the processor. The shock absorber monitoring system may then include a transmitter which is electrically connected to the accelerometer and may include a receiver, which is electrically connected to the processor. For example, the transmitter may be in the form of an output buffer and the receiver may be in the form of an input buffer, or the transmitter and receiver may be a radio frequency (RF) transmitter/receiver pair, matched to transmit and receive the acceleration signal by means of a RF signal.

The shock absorber monitoring system may include a power supply, in use to supply electrical power to any one, or more of the accelerometer, the processor and the indicator.

The shock absorber monitoring system may include a communication port connected to the processor, in use to communicate the results of the calculations to a remote device, such as a personal computer.

An embodiment of the invention will now be described, by way of example, with reference to the following drawings.

In the drawings,

Figure 1 shows a three dimensional view of a shock absorber monitoring system in accordance with the invention, in use;

Figure 2 shows a schematic block diagram of a shock absorber monitoring system in accordance with the invention; and

Figure 3 shows a graph of a series of acceleration values plotted over time.

In the drawings, reference numeral 10 generally indicates a shock absorber monitoring system. The shock absorber monitoring system 10 includes an accelerometer 12 connected by means of a coiled electrical cable 20 into a handheld housing 18. In this example the accelerometer is an ADXL202AE device manufactured by Analog Devices. The accelerometer is a dual-axis accelerometer, of which only one axis is selectively used to determine the damping factor. On the handheld housing 18 an indicator 14 and a membrane keypad 46 are provided. The shock absorber monitoring system 10 also includes a buzzer (not shown) which gives audio signals to a user during use of the shock absorber mounting system 10. The shock absorber monitoring system 10 is used to monitor a suspension (not shown) of a vehicle 16 proximate a location where a shock absorber (not shown) is installed. The shock absorber monitoring system 10 is used to determine a damping factor of the shock absorber at a wheel 11, close to where the accelerometer 12 is attached.

The accelerometer 12 has attachment means in the form of a magnetic coupling device (not shown) by which it is removably attached to a metal body of the vehicle 16 so that one of the two axes of the accelerometer is substantially perpendicular to a ground surface.

In Figure 2, a schematic block diagram shows the shock absorber monitoring system 10 in more detail. The accelerometer 12 is connected via signal conditioning circuitry 30 through the coiled electrical cable 20 into the housing 18 to an analog input of a micro processor 32. The signal conditioning circuitry 30 include two cascaded operational amplifiers (not shown), of which the first amplifier is a unity gain buffer and the second amplifier is a subtractor/amplifier tuned to cancel the effect of gravity on the accelerometer and to amplify the acceleration signal. The operational amplifiers are LM358 type devices. The micro processor may be a MC681HC908MR16 available from Motorola. The micro processor 32 is connected in circuitry to static random access memory (SRAM) 34 for temporary storage of data, to flash random access memory (Flash RAM) 36 for storage of non-volatile data, such as executable code for the processor 32, and to a communication interface 38. The SRAM 34 is 8 bits wide with a storage capacity of 8k bytes and the Flash RAM 36 is 8 bits wide with a storage capacity of 128k bytes. The Flash RAM 36 has a series data- and address bus interface, for communicating with the micro processor 32, while the SRAM 34 has a dedicated data- and address bus interface to the micro processor 32. The communication interface is a RS232 driver, capable of a data transfer rate of 19200 baud. The micro processor 32, SRAM 34, Flash RAM 36 and

communication interface 38 provide a mathematical processing capability to the shock absorber monitoring system 10.

The shock absorber monitoring system 10 also includes a battery charger 40 connected to a power supply 42 in the form of a rechargeable battery to supply power to the shock absorber monitoring system 10. The battery charger regulates the supply voltage to the shock absorber monitoring system 10 to 5V and provides a supply of electrical power to charge the battery which is a 7.2V Nickel-Cadmium battery. The battery charger 40 and the communication interface 38 are connected via a connector 44 to a remote device such as a personal computer (not shown). Also connected to the micro processor 32 is the indicator 14 in the form of a liquid crystal display (LCD) with a graphic display capability. The LCD display is a 128x64 dots display from Orion Display Technologies (ODT) with an 8 bit wide data/address bus interface to the processor 32. The membrane keypad 46 is also connected directly to the micro processor 32 for providing a user interface to the micro processor 32. The keypad is a matrix keypad with 4 rows and 4 columns connected to the 8 bit data bus of the processor 32 with in-line-, and pull-up resistors (not shown).

The micro processor 32 has internal processor Flash RAM (not shown) on which executable code, that directs the operation of the micro processor 32, is stored.

The executable code includes commands to read keystrokes from a user via the membrane keypad 46, and includes commands to display information to the user via the indicator 14. Typically the user will be requested to indicate which shock absorber is to be tested (left front, right front, left rear, right rear), the user will also be requested to supply vehicle information, and the results of tests shall be displayed on the indicator 14.

The Flash RAM 36 stores non-volatile data such as pre-programmed screens of the indicator 14. In addition, the Flash RAM 36 also stores commands to direct the processor 32 to perform mathematical calculations in order to determine the damping factor of the shock absorber.

In use, the shock absorber monitoring system 10 is switched on and off with a key on the keypad 46, the correct measurement range for the type of shock absorber to be tested is selected on the keypad 46, the accelerometer 12 is attached to the vehicle body 16 and the vehicle body 16 is displaced on a suspension by rapidly pushing down on the body so as to compress the shock absorber in the suspension and to allow the suspension to settle. As the suspension settles incidental acceleration values of the vehicle body 16 on the suspension are recorded at discrete time intervals over a period of time, which is typically the settling period of the suspension. The series of values, when plotted over time, is indicated in the graph in Figure 3 by reference numeral 50.

The processor 32 mathematically integrates the series of incidental acceleration values thereby to produce a range of incidental velocity values (not illustrated in Figure 3).

The series of incidental velocity values are integrated to produce a series of incidental displacement values. The series of incidental displacement values is indicated in the graph in Figure 3 by reference numeral 52.

A formula 54 (see below) providing a theoretical time domain solution to the displacement value of a differential equation is also stored in the processor Flash RAM. With properly selected tuning values the formula 54 will produce a range of displacement values that may produce a similar graph as indicated by reference numeral 52 in Figure 3. The formula 54 for the time domain solution of the displacement value is as follows:

$$Y = 2\,(1-(PK/2t)(T/t))\,Y_1 - (T^2/t^2 - 2(PK/2t^2)+1)\,Y_0 + K\,(T^2/t^2)\,MV \qquad (54)$$

Where

P = damping constant

K = spring constant

t = lag

T = discrete time interval

MV = initial displacement

Y = displacement at time interval (T)

$Y_1$ = displacement in previous time interval (T-1)

$Y_0$ = displacement at time interval (T-2)

A range of theoretical displacement values generated by formula 54 is mathematically corelated to the calculated incidental displacement values by means of a curve fitting algorithm such as the "Nelder Mead" algorithm. The curve fitting algorithm iteratively adjusts the values for P, K and t until the series of Y values approximate the series of measured displacement values within tolerable limits. It is to be appreciated that any other curve fitting algorithm can be used to fit the range of theoretical displacement values to the calculated range of values. The values for the damping constant (P), the spring constant (K) and the lag (t) is thus determined.

The damping factor (P) is a measure of the effective damping force of the measured shock absorber.

By comparing the damping factor (P) to a previously stored quantitative damping factor from the manufacturer of the shock absorber, the processor 32 calculates whether the damping factor (P) is within tolerable limits of the quantitative damping factor.

The result of the calculation is then displayed on the indicator 14. For example, the indicator 14 will display a percentage value of the effectiveness of the shock absorber and will indicate if the shock absorber should be replaced or not.

The Inventor believes that the shock absorber monitoring system 10, as illustrated, provides a system for determining the damping factor of a shock absorber which is accurate and is easily effected by simply attaching the accelerometer 12 to the vehicle and displacing the vehicle downwardly.

DATED THIS 26TH DAY OF NOVEMBER 2002

ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS

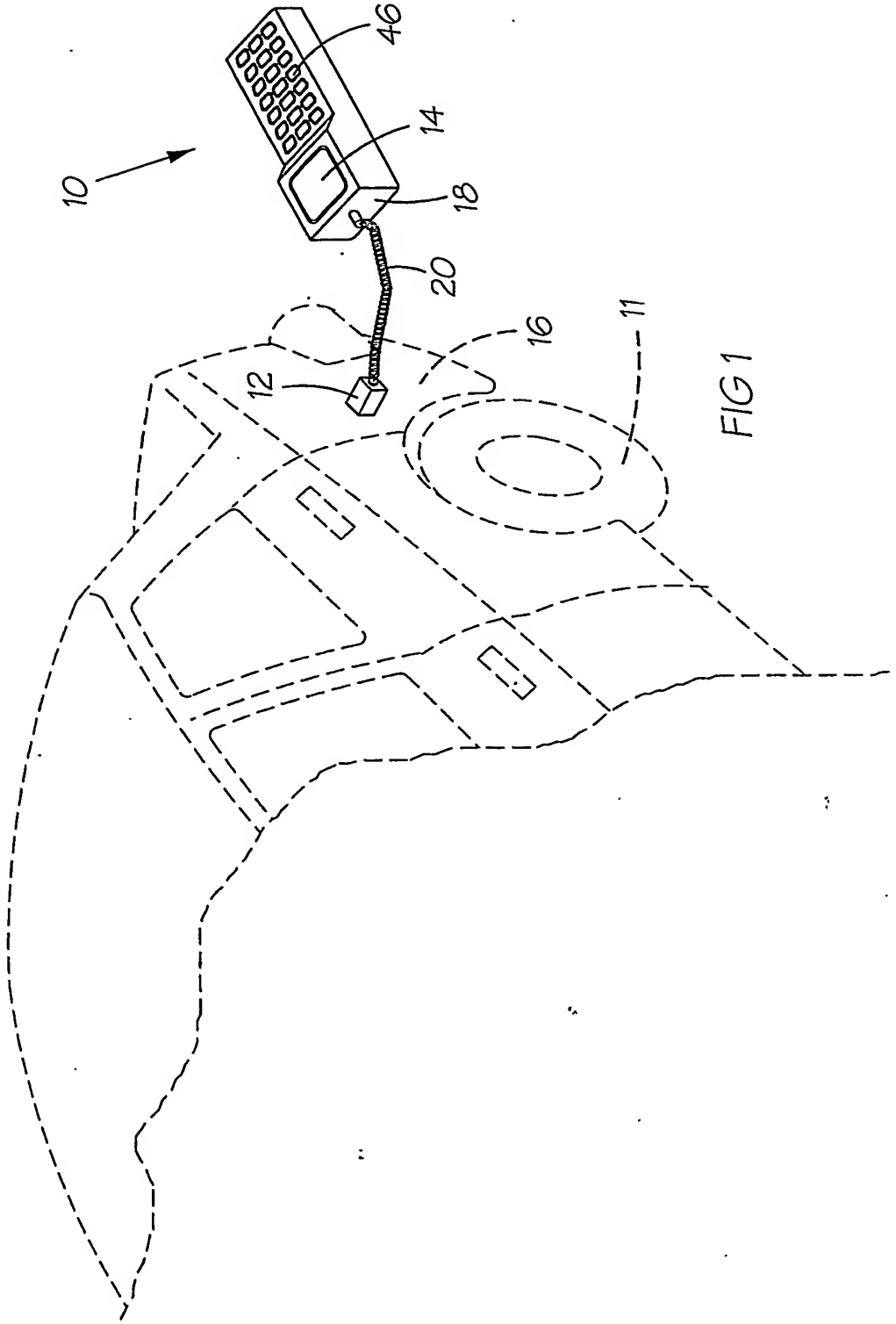



FIG 1

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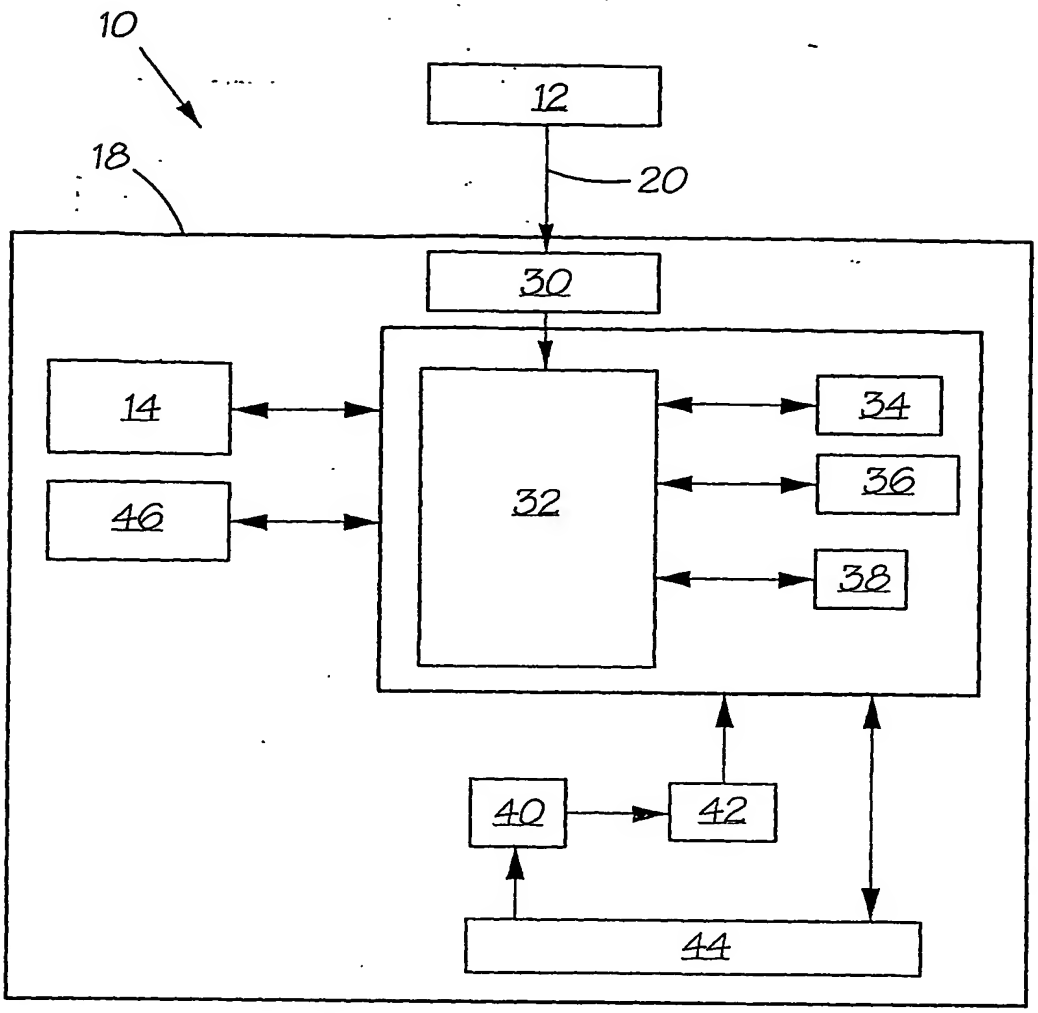


FIG 2

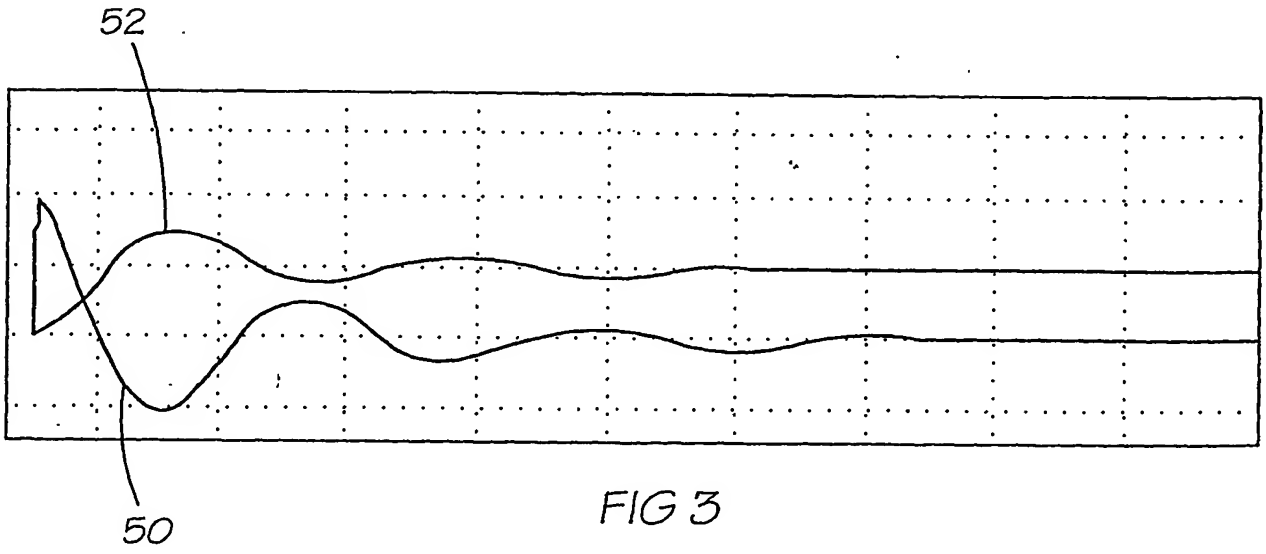


FIG 3

ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS